MISSOURI RIVER

STUDY OF THE LATERAL MIXING CHARACTERISTICS OF THE MISSOURI RIVER BELOW GAVINS POINT AND FORT RANDALL DAMS

U.S. ARMY ENGINEER DIVISION, MISSOURI RIVER
CORPS OF ENGINEERS
OMAHA, NEBRASKA

MRD SEDIMENT SERIES

NO. 20

1980

V. SUMMARY AND RECOMMENDATIONS

Two continuous injection dye studies were conducted below Gavins Point and Fort Randall dams on the Missouri River above Yankton, South Dakota. Two hundred and fifty pounds (113.6 kg) of Rhodamine WT dye were injected into the river near the left bank downstream of each of the powerhouses. The period of injection was approximately 10 hours.

The primary objectives of the two studies were to determine the time and distance required for cross-channel mixing and to assess the effect of islands on the rate of lateral mixing. The flow from Fort Randall was unsteady during the period of study. This afforded the opportunity to examine lateral mixing under both steady and unsteady flow conditions.

Determination of the rate of lateral mixing was made through calibration of a two-dimensional transport model. The values of lateral mixing coefficients required to calibrate the model were compared to values obtained in laboratory and other studies. The model was also used to assess the effect of islands and unsteady flow.

The model results for Gavins Point Dam from river miles 845.1 through 839.1 are good to excellent. The model predictions generally fall within the scatter of the data. Predictions in general have less than 10 percent error.

The worst model results were obtained at river mile 836.1. This cross section is located immediately below the large island near Yankton. Part of the appearance problem seems to be that the observed data were collected on the rising limb of the dye cloud.

Model results below 836.1, river miles 832.8 through 823.0, are mixed. The predictions follow the trend of the data fairly well, but absolute errors at single points range as high as 50 percent.

Results of the study indicate that at 34,900 cfs (988 m^3/sec) material released near the left bank at the powerhouse will be fairly well mixed across the channel in 22 mi (35.4 km). Results from the calibrated model indicate that a time of approximately 9 hours is required for traces of material to reach mile 823.0 from mile 845.1. This is a velocity of 2.46 mph (3.96 km/hr).

The effect of islands on lateral mixing appears to be quite significant. Lateral mixing coefficients above Yankton in reaches free of islands were consistent with other laboratory and field studies at 0.25 YU_*. Below Yankton E_z values of from 1.5 to 11.8 YU_* were required to simulate the greatly increased mixing. These values are 2.5 to 19.7 times the 0.6 YU_* found by Yotsukura et al. (Reference 1) and 5 to 39 times the values used in Reference 2.

In future studies additional velocity and dye data upstream, downstream, and adjacent to islands would be desirable. This would help define the precise effect of a given island as opposed to a reach with several islands as was done here.

This model results on the Fort Randall reach are not generally as good as those for Gavins Point. Part of the difference seems to come from a greater number of islands throughout the reach and the unsteadiness of the flow.

Results of the study indicate that at 33,900 cfs (960 m^3/sec) material released near the left bank at the powerhouse will be approximately 60 to 70 percent mixed in 18 mi (29 km).

The exact distance for complete mixing is not precisely known because of lack of dye data below mile 902.8. It is a reasonable assumption that complete mixing would occur before Niobrara at mile 885.6, and probably sooner.

Results from the calibrated model indicate that a time of approximately 7½ hours is required for traces of material to reach mile 902.8 from mile 920.9. This is a velocity of 2.4 mph (3.86 km/hr). The accuracy or worth of these numbers is unknown because of the unsteady flow.

The effect of islands on lateral mixing is again apparent, although not to the extent found below Yankton in the Gavins Point reach. Values for E_z ranged from 0.5 YU_* to 1.8 YU_*. A value of 0.5 YU_* is slightly less than the 0.6 YU_* reported by Yotsukura et al. (Reference 1), while 1.8 is (obviously) three times as much. There is little doubt that islands increase the rate of lateral mixing.

Unsteady flow affected the results in two ways. First, the changing value of discharge changed the dilution ratio and hence, the plateau concentration in early periods of the study. Second, the changing velocities in the reach made it necessary to make adjustments to the observed velocities in the model to achieve correctly timed results. The adjustments were made uniformly across each section to speed or slow the predicted arrival time to match observed results. While this procedure achieves reasonable looking answers, it is not satisfactory. A better solution would be to use a one-dimensional flow model to pass cross-section average velocities to the flow model. The average could be used as a guide to adjust point values up or down. If the transport model is used often in unsteady conditions, this would be a desirable option.

In general, the study objectives were met. Lateral mixing rates and travel times were successfully determined below both

Gavins Point and Fort Randall dams. The calibrated models of the two reaches may be used to determine the mixing pattern from other constituents and under a variety of source conditions by varying the upstream boundary conditions on the model. Mixing at other discharges can be simulated by making appropriate adjustments in velocities and by adjusting lateral mixing coefficient values for changes in depth (Appendix H).